MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2016/2017

ETN2016 – ANALOG COMMUNICATIONS

(All Section / Groups)

27 FEBRUARY 2017
9.00 a.m - 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 9 pages (including the cover page) with 4 Questions only.

2. Attempt all of the **FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Consider a periodic signal $m(t)$ shown in Figure Q1.

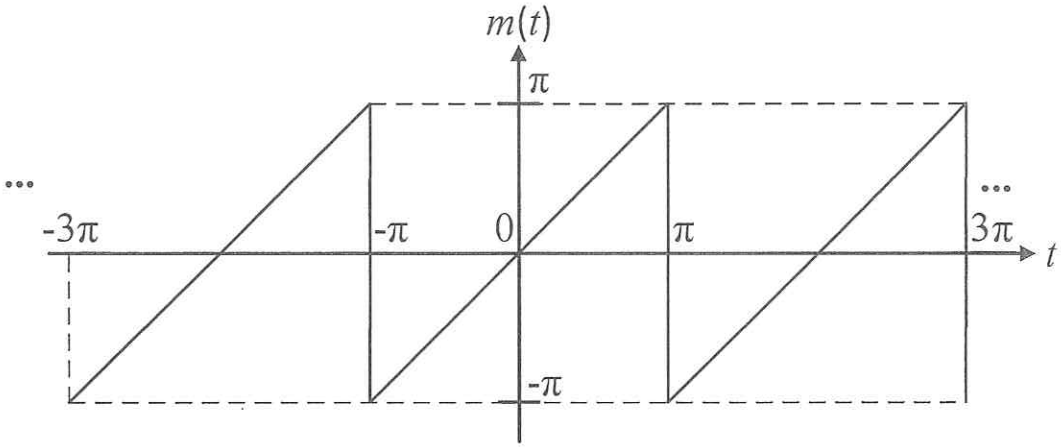

Figure Q1: Periodic signal $m(t)$.

(i) Determine the trigonometric Fourier series of $m(t)$.

[11 marks]

(i) Sketch the single sided magnitude spectrum of $m(t)$ up to the 4th harmonic, i.e., $n = 0, 1, 2, 3, 4$, where $f = nf_0$ is the nth harmonic frequency, $f_0 = \frac{1}{T_0}$, and T_0 denotes the period of $m(t)$.

[2.5 marks]

(ii) Sketch the double sided magnitude spectrum of $m(t)$ for $n = -4, -3, -2, -1, 0, 1, 2, 3, 4$.

[2.5 marks]

(b) The Fourier transform of $w(t)$ is given as $W(f) = \frac{j2\pi f}{1 + j2\pi f}$. By applying the properties of the Fourier transform, determine the Fourier transform for the following signals:

(i) $x(t) = \left(\frac{1}{2\pi}\right)^3 \frac{d^3 w(t)}{dt^3}$

[3 marks]

(ii) $y(t) = w\left(\frac{t-1}{5}\right)$

[3 marks]

(iii) $z(t) = w(3t)e^{j2t}$

[3 marks]

Continued .....

Question 2

(a) With the aid of diagrams, distinguish between a baseband signal and a bandpass signal.

[5 marks]

(b) A message signal $m(t) = A_m \cos(2\pi f_m t)$ modulates a carrier signal $s_c(t) = A_c \cos(\omega_c t)$ using a double sideband large carrier (DSB-LC) modulation scheme. The total transmission power of the DSB-LC modulated signal is 15 kW and the power contained in the lower sideband of the modulated signal is 1.990 kW.

(i) Determine the power contained in the upper sideband of the modulated signal.

[2 marks]

(ii) Find the carrier power.

[2 marks]

(iii) Calculate the modulation index.

[3 marks]

(iv) Compute the power efficiency of this DSB-LC transmission scheme.

[3 marks]

(v) Assume that the DSB-LC modulated signal is transmitted over an ideal channel that is noise free. Can the message signal be recovered from the received signal by using an envelope detector? Justify your answer.

[2 marks]

(vi) Assume that f_m = 3 kHz. Determine the bandwidth of the DSB-LC modulated signal.

[1 mark]

(vii) State two drawbacks of DSB-LC.

[2 marks]

(c) Discuss the differences between single sideband (SSB) modulation and vestigial sideband (VSB) modulation in terms of the spectrum of the modulated signal.

[5 marks]

Continued .....

Question 3

(a) With the aid of equations, distinguish between frequency modulation (FM) and phase modulation (PM).

[3 marks]

(b) A source produces an analog output signal $m(t) = A_m \cos(2\pi f_m t)$. The signal is angle-modulated and the modulated signal can be expressed as follows:

$$s(t) = 4\cos\left\{(2\pi)(2\times10^6 t) + 2\sin\left[(2\pi)(2\times10^4 t)\right]\right\}$$

(i) Is $s(t)$ frequency modulated (FM), phase modulated (PM), or neither? Justify your answer.

[2 marks]

(ii) Determine the expression of the instantaneous phase of $s(t)$.

[1.5 marks]

(iii) Determine the expression of the phase deviation of $s(t)$.

[1.5 marks]

(iv) Calculate the average power of $s(t)$ developed across a $1\,\Omega$ resistor.

[2 marks]

(v) Compute the percentage of power contained in the carrier frequency.

[2 marks]

(vi) Compute the percentage of power contained in the sidebands.

[3 marks]

(vii) Calculate the bandwidth of $s(t)$ by using the table of Bessel functions of the first kind.

[2 marks]

(viii) The FM signal is passed through an ideal bandpass filter (BPF), which has a centre frequency of 2 MHz, a bandwidth of 60 kHz, and a gain of unity. Determine the number of sidebands that will pass through the BPF without being attenuated.

[2 marks]

(c) With the aid of diagram, explain in detail the role and the working principle of pre-emphasis and de-emphasis in an FM receiver.

[6 marks]

Continued .....

Question 4

(a) Figure Q4 shows the block diagram of an amplitude modulation (AM) receiver using envelope detection. The input to the envelope detector is given by $x(t)=s(t)+n(t)$, where $s(t)=A_c\left[1+k_a m(t)\right]\cos(2\pi f_c t)$ is the amplitude modulated signal, $n(t)$ represents the noise, $A_c\cos(\omega_c t)$ is the carrier signal, $m(t)$ is the message signal, and k_a is the amplitude sensitivity of the modulator. Assume that the band-pass filter has unity gain and an equivalent noise bandwidth of B_T, $E\left[m(t)\right]=0$, and $P=E\left[m^2(t)\right]$, where $E[\ ]$ is the expectation operator.

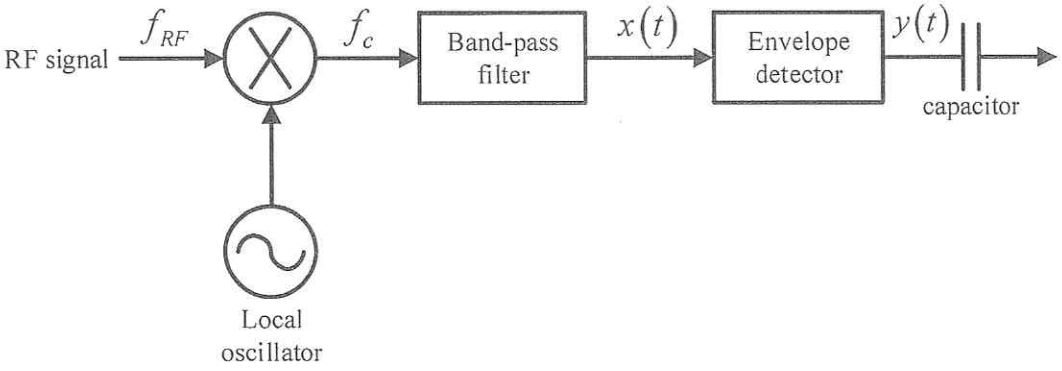

Figure Q4: Block diagram of an AM receiver using envelope detection.

(i) Explain the role of the bandpass filter and the capacitor in Figure Q4.

[3 marks]

(ii) Derive an expression for the pre-detection signal-to-noise ratio (SNR) of the AM receiver.

[6 marks]

(b) Define the term "image frequency". Propose one method to mitigate the image frequency problem.

[3 marks]

(c) Design a superheterodyne AM radio receiver that can be tuned to receive AM broadcasts from 510 kHz to 1600 kHz with an intermediate frequency (IF) of 455 kHz by using high-side injection (high tracking).

(i) Calculate the range of frequencies that must be generated by the local oscillator (LO).

[3 marks]

(ii) Compute the range of image frequencies.

[3 marks]

(iii) Determine the LO frequency and the image frequency when the receiver is tuned to a station at 1200 kHz.

[3 marks]

Continued .....

Question 4

(c)

(iv) Assume that the input filter (image rejection filter) has a 28 kHz passband bandwidth and 40 dB/decade roll-off. Calculate the image rejection ratio (IRR) when the receiver is tuned to a station at 1200 kHz.

[4 marks]

Continued .....

APPENDIX

Fourier Transform Pairs

$x(t)$	$X(f)$
$\delta(t)$	1
$\delta(t-t_o)$	$e^{-j2\pi ft_o}$
1	$\delta(f)$
$e^{j2\pi f_o t}$	$\delta(f-f_o)$
$u(t)$	$\frac{1}{2}\delta(f)+\frac{1}{j2\pi f}$
$e^{-at}u(t)$	$\frac{1}{a+j2\pi f}$, for $a>0$
$e^{at}u(-t)$	$\frac{1}{a-j2\pi f}$, for $a>0$
$e^{-a\lvert t\rvert}$	$\frac{2a}{a^2+(2\pi f)^2}$, for $a>0$
$rect\left(\frac{t}{T}\right)$	$T\text{sinc}(fT)$
$\text{sinc}(2Wt)$	$\frac{1}{2W}rect\left(\frac{f}{2W}\right)$
$\Delta\left(\frac{t}{T}\right)$	$\frac{T}{2}\text{sinc}^2\left(\frac{fT}{2}\right)$
$W\text{sinc}^2(Wt)$	$\Delta\left(\frac{f}{2W}\right)$
$e^{-\pi t^2}$	$e^{-\pi f^2}$
$\cos(2\pi f_o t)$	$\frac{1}{2}\delta(f-f_o)+\frac{1}{2}\delta(f+f_o)$
$\sin(2\pi f_o t)$	$\frac{1}{2j}[\delta(f-f_o)-\delta(f+f_o)]$

Continued .....

Fourier Transform Properties

Let $x(t) \Leftrightarrow X(f)$, $x_1(t) \Leftrightarrow X_1(f)$ and $x_2(t) \Leftrightarrow X_2(f)$; and a, b, t_o and f_o scalar quantities.	
Linearity	$ax_1(t)+bx_2(t) \Leftrightarrow aX_1(f)+bX_2(f)$
Scaling ($a \neq 0$)	$x(at) \Leftrightarrow \frac{1}{\lvert a \rvert} X\left(\frac{f}{a}\right)$
Time Shifting	$x(t-t_o) \Leftrightarrow X(f)e^{-j2\pi f t_o}$
Frequency Shifting	$x(t)e^{j2\pi f_o t} \Leftrightarrow X(f-f_o)$
Time Convolution	$x_1(t) * x_2(t) \Leftrightarrow X_1(f)X_2(f)$
Frequency Convolution	$x_1(t)x_2(t) \Leftrightarrow X_1(f) * X_2(f)$
Time Differentiation	$\frac{d^n}{dt^n}x(t) \Leftrightarrow (j2\pi f)^n X(f)$
Frequency Differentiation	$(-jt)^n x(t) \Leftrightarrow \frac{d^n}{df^n}X(f)$
Time Integration	$\int_{-\infty}^{t} x(\tilde{t})d\tilde{t} \Leftrightarrow \frac{X(f)}{j2\pi f}+\frac{1}{2}X(0)\delta(f)$
Frequency Integration	$x(t)u(t) \Leftrightarrow \int_{-\infty}^{f} X(\tilde{f})d\tilde{f}$

Useful Trigonometric Identities

$$\sin A \sin B = \frac{1}{2}\left[\cos(A-B)-\cos(A+B)\right]$$

$$\cos A \cos B = \frac{1}{2}\left[\cos(A+B)+\cos(A-B)\right]$$

$$\sin(A+B) = \sin A \cos B + \cos A \sin B$$

$$\cos(A+B) = \cos A \cos B - \sin A \sin B$$

$$\sin\theta = \frac{1}{2j}\left[e^{j\theta}-e^{-j\theta}\right]$$

$$\cos\theta = \frac{1}{2}\left[e^{j\theta}+e^{-j\theta}\right]$$

Continued .....

Table of Bessel functions of the first kind

	$J_n(\beta)$							
n	$\beta = 0.2$	$\beta = 0.3$	$\beta = 0.5$	$\beta = 0.7$	$\beta = 1.0$	$\beta = 2.0$	$\beta = 3.0$	$\beta = 5.0$
0	0.990	0.978	0.938	0.881	0.765	0.224	-0.260	-0.178
1	0.100	0.148	0.242	0.329	0.440	0.577	0.339	-0.328
2	0.005	0.011	0.031	0.059	0.115	0.353	0.486	0.047
3		0.001	0.003	0.007	0.020	0.129	0.309	0.365
4				0.001	0.002	0.034	0.132	0.391
5						0.007	0.043	0.261
6						0.001	0.011	0.131
7							0.003	0.053
8								0.018
9								0.006
10								0.001

End of Paper